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CHLORITOID FROM DUTCHESS COUNTY NEW YORK

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Chloritoid is a mineral that is not yet well known. Its crystallographic symmetry and its chemical composition are disputed.¹ More than 50 years ago Tschermak² contended that the symmetry was monoclinic and he also assigned a chemical formula to it. To be sure, his contentions are still accepted by the majority of mineralogists, but a good many writers have also reported results in apparent disagreement with Tschermak's observations. New, and rather decisive data on chloritoid from a new locality in Dutchess County should therefore be of some value.

1. OCCURRENCE

The material was collected on the east slope of Clove Valley, Dutchess County, N. Y. The exact locality is: northwest spur of hill 1200', $1\frac{1}{2}$ miles north-northeast of the old Clove Valley Station (printed "Clove Valley"), Clove quadrangle, N. Y. The valley is underlain by late Cambrian dolomitic marble, and on the slopes to the west and east, phyllitic schists overlie the marble in the general form of an eroded anticline. On the east slopes, the rock carries crystalloblasts of biotite and garnet, and locally also kyanite and staurolite.

The ledge from which the specimens were taken measures about 40 feet in diameter. Specks of dark green, brilliant chloritoid, up to $\frac{1}{4}$ inch in diameter, attract immediate attention. In addition a few

¹ For general information see, for instance: Rosenbusch's *Mikroskopische Physiographie der Mineralien und Gesteine* by O. Mügge, 1927, Bd. I, 2, p. 612. Here are given 53 references to the literature.

² G. Tschermak and L. Sipöcz, Die Clintonitgruppe: *Sitzber. Akad. Wiss. Wien*, vol. 78, 1878; *Z. Krist.*, vol. 3, p. 506, 1879.

crystalloblasts of garnet and partly altered staurolite and biotite are encountered. Some opaque ore mineral is also present. The groundmass consists of sericite and quartz. As yet, this is the only locality discovered in this particular area; the rock represents a small lens within the dark biotite-sericite schist series.

2. CHEMICAL FORMULA

The chloritoid occurs with all the characteristics of this mineral: crystalloblasts scattered all through the rock with no visible relation to the directions of schistosity, and always containing inclusions, especially quartz and the typical dustlike particles so frequently described, as well as small grains of garnet and tiny flakes of muscovite.

Such crystalloblasts measuring 3 to 5 mm. across and usually less than 1 mm. thick were separated and a chemical analysis conducted (see Table I, column 1). As a comparison an analysis by

TABLE I. CHEMICAL ANALYSES OF CHLORITOID WITH INCLUSIONS (1) FROM DUTCHESS COUNTY, NEW YORK, (2) FROM KALGOORLIE, W. AUSTRALIA

	1	2
SiO ₂	29.5	29.03
TiO ₂	1.2	1.46
Al ₂ O ₃	38.1	35.62
Fe ₂ O ₃	2.3	2.78
FeO	21.5	21.89
MnO	0.2	0.45
MgO	1.6	1.47
CaO	trace	0.93
H ₂ O	5.6*	7.05
Sum	100.0	100.68

* H₂O determined by difference.

Simpson³ is given (column 2). From a microscopic investigation of his material Simpson concluded that it was contaminated with quartz and rutile. With the help of Lunge's solution he also managed to determine separately the silica present as free quartz and found it to be 7.35 per cent. After these amounts were subtracted from his analysis the molecular proportions came out close to

³ E. S. Simpson, Contrib. Mineral. of W. Australia: *J. Roy. Soc. W. Australia*, vol. 16, p. 27, 1930. See also *W. Austral. Geol. Surv.*, vol. 64, p. 64, 1915.

$\text{H}_2\text{O}:\text{R}_2\text{O}_3:\text{RO}:\text{SiO}_2 = 1:1:1:1$, in agreement with Tschermak's results. With essentially the same result Niggli⁴ had recalculated an analysis of chloritoid from Nadels, Switzerland. The analysis of the chloritoid from Dutchess County represents an analogous case: after subtraction of the contaminations, the nature and amount of which can be fairly well estimated with the microscope, this analysis would correspond closely to the proportions given above. In order, however, to obtain a more definite result a chemical separation of the contaminating mineral particles was undertaken.

Chloritoid itself is soluble in H_2SO_4 , but the enclosed minerals are not soluble in acids. The material was therefore digested with

TABLE II. CHLORITOID WITH INCLUSIONS, FROM DUTCHESS COUNTY, NEW YORK

	Soluble in H_2SO_4	Residue	Total
SiO_2	20.7	8.1	28.8
TiO_2	1.1	trace	1.1
Al_2O_3	33.6	4.8	38.4
Fe_2O_3	21.5	1.8	23.3
FeO			
MnO	0.2	present	0.2
MgO	1.5	trace	1.5
CaO	trace	trace	trace
H_2O	—	—	6.7*
Sum	78.6	14.7	100.00

* H_2O determined by difference.

sulfuric acid and the procedure described by Treadwell as "Determination of 'soluble' silica" was followed. The soluble portion and the residue⁵ were then analyzed separately. The results as given in Table II are in good agreement with those from the first analysis (Table I).

The portion soluble in H_2SO_4 recalculated to 100% thus corresponds to the composition of pure chloritoid (see Table III).

The present chemical investigations thus definitely show that the composition of chloritoid from Dutchess County can be ex-

⁴ P. Niggli, Die Chloritoidschiefer des Gotthardmassives: *Beitr. Geol. Karte Schweiz*, vol. 36, p. 20, 1913.

⁵ This residue was also investigated with the microscope. It contained in addition to quartz some garnet and muscovite as well as an opaque, dustlike substance the nature of which could not be ascertained.

pressed by the following formula: $\text{H}_2\text{FeAl}_2\text{SiO}_7$ (in which a small amount of Fe^{III} and Mg substitutes for Al and Fe^{II} respectively).⁶ This formula corresponds to that proposed by Tschermak and afterwards accepted by several investigators. But it may be worth while adding that the existence of such a chloritoid does not necessarily exclude the possibility that some other chloritoid or chloritoid-like minerals may be possessed of different chemical formulae.⁷

TABLE III. CHEMICAL COMPOSITION OF CHLORITOID FROM DUTCHESS COUNTY, NEW YORK

	Weight %	Mol. prop.	
SiO_2	24.4	406	406
TiO_2	1.3	16	
Al_2O_3	39.6	388	403
Fe_2O_3	2.4	15	
FeO	23.0	320	384*
MnO	0.2	3	
MgO	1.8	45	
CaO	trace		
H_2O	7.3	405	405
Sum	100.0		

* Incl. TiO_2 .

3. OPTICAL PROPERTIES

The pleochroism of the chloritoid from Dutchess County is unusually weak, but corresponds to the known absorption scheme of the chloritoids:

α = pale gray-green

β = slate blue

γ = yellow, almost colorless

The indices of refraction are as follows:

$$\alpha = 1.722, \beta = 1.725, \gamma = 1.728, \text{ all } \pm 0.002.$$

⁶ As first proposed by Niggli, later by Simpson, and adopted, for instance, by Winchell in his *Elements of Optical Mineralogy*, brittle mica with no appreciable amount of Mg or Mn should be called "chloritoid."

⁷ Cf. for instance, F. Machatschki, *Steirische Chloritoidschiefer: Geol. Archiv II*, p. 188, Königsberg 1923; C. Fridländer, *Der Chloritoid von Crestlianderstobel, Schweiz: Min. Petr. Mitt.*, vol. 9, p. 247, 1930.

The optic angle is variable, but always positive and usually of a medium value, around 60° . The dispersion is anomalous, for in convergent light the hyperbolas do not show the ordinary colored rims of blue and red, but on the convex side they are green and on the concave side yellow. A probable cause for this is that the optic angle has its greatest value at intermediate wave lengths.⁸

The optical orientation was determined with a Fedorov stage which proved itself an excellent tool for this investigation. Not only was the optical orientation of several individual crystals of

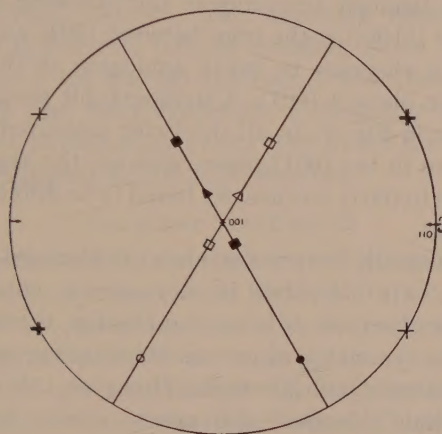


FIG. 1. Stereographic projection of a twin of chloritoid projected on the base, (001). Composition face is (001). Twin axis \perp (110). Open symbols refer to one individual, solid symbols to the second individual, which is in twin position to the first one.

$O = \alpha$, $+ = \beta$, $\Delta = \gamma$, \square = optic axis.

chloritoid thus established, but also a good survey of the range of variability of the optical properties could be obtained. Thus it was found that the direction β always lies in the cleavage plane, (001), whereas the direction γ makes an angle of 5° to 22° with the normal to (001).

These observations establish the monoclinic symmetry of the Dutchess County chloritoid, for although each individual measurement with the Fedorov stage cannot be conducted with greater accuracy than about $\pm 1^\circ$, the fact should be borne in mind that in all the measurements (comprising 20 to 30 different crystals),

⁸ Cf. J. Schetelig, *Mineral. Studien I*, Norsk Geol. Tidsskrift, vol. 2, No. 9, 1913.

β was always observed to lie in the cleavage plane, whereas α and γ varied conspicuously. These crystals thus represent a series of chloritoids in which the direction of the index β remains constant, although the optical indicatrix is otherwise susceptible of great variations both in position and in shape, and the unavoidable conclusion must be that β is held fast by a symmetry condition, in this case by the monoclinic symmetry plane, to which it is normal, whereas α and γ vary in the symmetry plane.

A study of the twins leads to the same conclusion. All crystals observed were twinned according to the following law: the twin axis is the zone [110] (i.e. the edge between (001) and (110) if the crystallographic elements be taken analogous to those of mica); the composition plane is (001). A stereographic projection of such a twin is given in Fig. 1. In all the twins measured it was found that β remained in the (001)-plane, whereas the angle between γ and the normal to (001) was usually found to be different in the two twin individuals.

If polysynthetically twinned crystals of chloritoid are examined in which each twin individual is very narrow, confusing optical phenomena are observed. It is not improbable, therefore, that the alleged triclinic symmetry of certain chloritoid crystals is due to observations on such multiple twins. However, it is of course possible that triclinic chloritoid also exists—similar to the case of orthoclase and microcline, for instance—but there are no data on record actually proving the existence of any triclinic chloritoid.

THE PETROGRAPHY OF THE BEACON SANDSTONE OF SOUTH VICTORIA LAND*

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INTRODUCTION

Fifty-two sedimentary rock specimens of the Beacon Sandstone formation of South Victoria Land, Antarctica, have been examined petrographically. Gould, geologist of the Byrd Antarctic Expedition, 1928-30, collected 27 specimens in the Queen Maud Mountains. Fifteen duplicate specimens have been studied of those collected *in situ* in the Ferrar Glacier district by the National Antarctic Expedition, 1901-04. Ten duplicate specimens, mainly erratics from the Priestley Glacier moraine, Terra Nova Bay district, collected by the British Antarctic (*Terra Nova*) Expedition, 1910-13, have also been examined. Preliminary petrographical notes have been published by Prior (9) on five of the specimens collected by the National Antarctic Expedition.

GENERAL STATEMENTS

The Beacon Sandstone formation derived its name from Beacon Heights named by Armitage of the National Antarctic Expedition.

The rocks of the formation vary from shaly types to sandstones containing approximately 99 per cent quartz—from arkoses with an average of 45 per cent feldspar to conglomerates containing pebbles of chert, volcanic material, diabase (?), and mica schist. This series rests upon a pre-Cambrian basement complex of igneous and metamorphic rocks. The lower members of the formation contain upper Devonian fish plates, and in the upper beds are found wood fragments, seams of low-grade coal, and fossil plants belonging to the *Glossopteris* flora. The widespread occurrence of cross-bedding and the presence of coal seams indicate a continental origin of a great part of the series. The upper strata are probably Permo-Carboniferous, with deposits of Triassic (?) age at the top. These sediments were intruded in late Mesozoic or early Tertiary by diabase sills of great thickness.

The Beacon formation extends from Adelie Land through King George V and South Victoria Lands, and into Marie Byrd Land. (See fig. 1). This widespread series of rocks is reported by Ferrar

* Part of a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, in the University of Michigan.

This article is a preliminary paper on the geology and petrography of the Antarctic Continent which is in part complete and which will be published later in full.

(4) to be about 2,000 feet in thickness in the Ferrar Glacier region. Debenham (3) states that in the McMurdo Sound district the Beacon Sandstone is at least 3,000 feet in thickness. Priestley and Tilley (8) remark that the beds are 5,000 feet thick, and Gould (5) gives the thickness of the series in Mount Fridtjof Nansen as 7,000 feet, of which some 2,500 feet is composed of diabase intrusives.

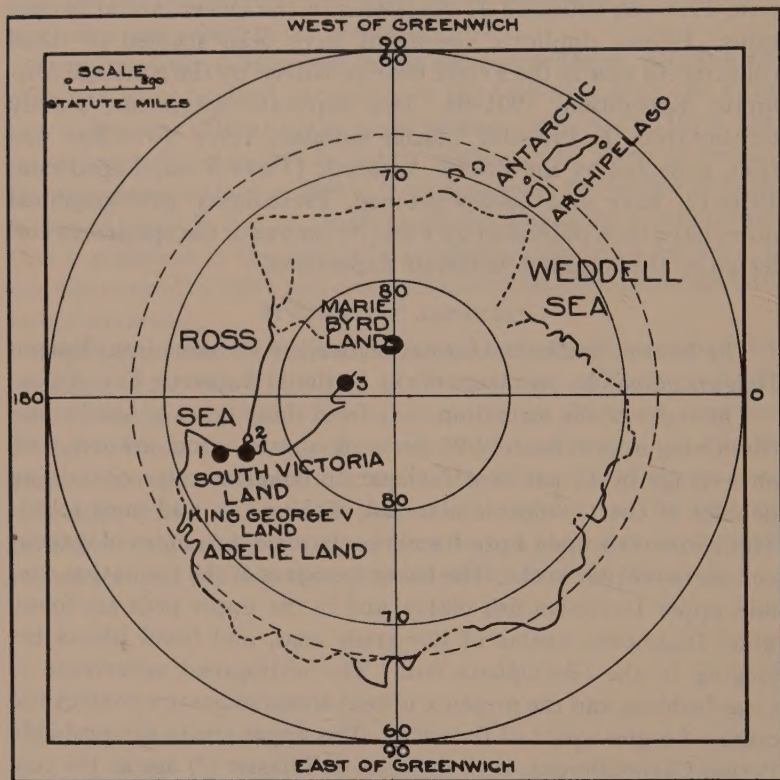


FIG. 1. Sketch map of Antarctica. (1) Terra Nova Bay district; (2) Ferrar Glacier district; (3) Mount Fridtjof Nansen district, Queen Maud Mountains, South Victoria Land.

The beds of the formation are practically horizontal, and occur in great fault-block mountains. According to Priestley and Tilley (8) the displacements of the beds are at least 5,000–6,000 feet.

PETROGRAPHY

BRITISH ANTARCTIC TERRA NOVA SPECIMENS. Ten duplicate specimens of Beacon formation rocks, of which the majority are

TABLE 1. MINERALS IN THE ROCKS OF THE BEACON FORMATION COLLECTED MAINLY FROM THE PRIESTLEY GLACIER MORaine, TERRA NOVA BAY DISTRICT

Minerals	Specimens							
	D88G	1270	1718	1842	1865	1938	A	B1
Quartz	x	x	x	x	x	x	x	x
Orthoclase			x	x	x	x		x
Microcline			x		x	x		x
Microperthite			x					x
Plagioclase		x	x		x		x	x
Muscovite	x		x	x				x
Biotite	x		x	x	x		x	x
Chlorite			x	x	x	x	x	x
Glauconite (?)					x			
Apatite	x	x	x	x	x	x	x	x
Zircon	x	x	x	x	x	x	x	x
Tourmaline	x		x	x	x	x		x
Garnet		x	x		x	x	x	
Diopside		x						
Hornblende	x	x	x		x			
Epidote			x			x		
Calcite		x		x	x	x		x
Natrolite					x			
Titanite	x	x	x	x		x	x	x
Rutile							x	
Ilmenite	x		x	x	x	x		x
Leucoxene	x	x	x	x	x	x		x
Magnetite		x	x	x	x	x		x
Pyrite		x			x			
Hematite	x							
Limonite			x	x	x	x		x
Chert	x		x	x		x		x
Diabase (?)			x		x	x		
Volcanic fragments					x	x		
Mica schist						x		

D88G. Black sandstone

1270. Contact sandstone

1718. Yellow sandstone

1842. Coarse sandstone

1865. Impure coarse sandstone

1938. Impure coarse sandstone

A. Shale

B1. Impure coarse sandstone

erratics from the Priestley Glacier moraine in the Terra Nova Bay district, have been examined. Table 1 shows the mineral contents of eight of the rocks, and it is to be noted that there are a number of mineral species and rock pebbles recorded which are not present in the sandstones of the type area in the Ferrar Glacier region.

TABLE 2. MINERALS IN THE ROCKS OF THE BEACON FORMATION OF THE TYPE AREA (FERRAR GLACIER DISTRICT)

Minerals	Specimens														
	630	638a	638b	639	641	642	643	644	663	673	677	678	679	682	683
Quartz	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Orthoclase	x				x	x	x	x	x	x		?		x	x
Microcline	x	x			x				x	x				x	x
Plagioclase	x	x			x	?		?	x	x		x		x	x
Muscovite	x	x		x	x	x	x		x	x			x	x	x
Biotite		x		x	x			x	x	x		x	x	x	x
Chlorite	x	x				x	x	x	x	x				x	x
Apatite	x	x		x	x	x		x	x	x	x	x	x	x	x
Zircon	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Tourmaline	x				x	x	x	x		x	x	x	x	x	
Garnet	x									x		x	x		
Epidote			x												x
Calcite			x			x									
Titanite	x	x	x			x	x		x	x					x
Rutile						x	x								
Ilmenite			x			x				x					
Leucoxene	x	x	x	x	x	x	x	x	x	x		x			x
Magnetite	x	x	x		x		x		x	x		x	x	x	
Hematite		x						x						x	
Limonite	x	x	x				x	x	x		x	x	x		
Chert		x											x		x

630. Arkose

638a. Conglomerate

638b. Siltstone

639. Sandstone

641. Coarse sandstone

642. Sandstone

643. Siltstone

644. Ferruginous sandstone

663. Fine-grained conglomerate

673. Quartzitic arkose pebble

677. Limonitic sandstone

678. Sandstone

679. Sandstone

682. Coarse sandstone

683. Sandstone

"Charred wood" remains are seen in specimens 1842, 1865, 1938, B, and C. In thin section the average grain size is 0.40 mm., and the particles, which are firmly cemented together, are subangular to rounded in outline. Microperthite, hornblende, glauconite (?), pyrite, and natrolite are present. Rutile grains are absent in the sandstones, whereas ilmenite, garnet, and dentated quartz are common. Diabase (?), chert, mica schist, and volcanic pebbles are noted. The quantitative measurements of the constituents of six of the sections were made with the improved Wentworth recording

TABLE 3. MINERALS IN THE ROCKS OF THE BEACON FORMATION OF MOUNT FRIDT-JOF NANSEN

Minerals	Specimens																	
	6a	8a	8b	9a	9c	10	11b	12b	13	14b	14c	17a	17b	17c	17d	18a	18b	
Quartz	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Orthoclase	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Microcline	x	x				x			x		x				x	x		
Plagioclase	x	x	x	x	x	x	x		x	x	x		x	x	x	x		
Muscovite	x				x		x		x		x			x	x	x		
Biotite	x	x	x	x	x	x	x	x	x		x	x		x	x		x	
Chlorite	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	
Apatite	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Zircon	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Tourmaline		?	?	x		?	x	x	?	x	x				x	x	x	
Garnet	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x	
Augite						x						x						
Epidote						?							x					
Clinozoisite														x				
Titanite	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Rutile	x				x	x	x	x	x	x	x				x	x	x	
Ilmenite	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Leucoxene	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Magnetite	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Hematite	x		x			x							x	x				
Limonite	x		x	x		x	x		x			x	x	x				

6a. Arkose

8a. Arkose

8b. Arkose

9a. Shaly arkose

9c. Micaceous arkose

10. Contact arkose

11b. Arkose

12b. Shaly arkose

13. Arkose

14b. Gray arkose

14c. "Spotted" arkose

17a. Contact quartzite

17b. Arkose with quartzitic arrangement of quartz

17c. Ferruginous micaceous arkose

17d. Arkose

18a. Arkose

18b. Slaty graywacke

micrometer. The quartz and feldspar percentages are variable, the quartz content in the thin sections varying from 40-97 per cent.

NATIONAL ANTARCTIC EXPEDITION SPECIMENS. Fifteen duplicate specimens of sedimentary rocks have been examined that were collected in Glacier Valley and Finger Mountain, Western Mountains, the Southwest arm of New Harbour Glacier, and the Inland Forts, South Victoria Land. Prior (9) (p. 134) has given preliminary reports on specimens 638*a*, 638*b*, 641, 642, and 679. Table 2 presents the mineralogy of the rocks. The average grain size of the particles

in thin section is 0.30 mm., and the grains which are practically all rounded or well-rounded, only a few of which are subangular, are in the majority of cases poorly cemented. Microperthite, hornblende, glauconite (?), pyrite, and natrolite are absent in these sections. Rutile as grains, ilmenite, and garnet occur sparingly, whereas dentated quartz and secondary quartz around well-rounded grains are common. Chert pebbles are rare. The percentages of the constituents of 10 of the sections were determined quantitatively, and

CHEMICAL ANALYSES OF ROCKS FROM THE BEACON FORMATION

	1	2	3*
SiO ₂	78.54	76.01	67.34
Al ₂ O ₃	10.81	13.29	15.52
Fe ₂ O ₃	0.35	0.52	0.63
FeO	1.42	1.75	4.87
MgO	0.80	0.60	2.01
CaO	0.73	0.72	0.40
Na ₂ O	3.32	3.33	1.59
K ₂ O	2.08	2.63	3.44
H ₂ O	0.95	0.25	2.93
H ₂ O—	0.09	0.27	0.17
TiO ₂	0.65	0.31	0.89
P ₂ O ₅	0.15	0.37	0.15
MnO	0.06	0.01	0.04
CO ₂	n.d.	0.06	n.d.
	<hr/> 99.95	<hr/> 100.12	<hr/> 99.98

1. Arkose (specimen 6a). Mount Fridtjof Nansen. Analyst, Ellestad.

2. Arkose. Upper Glacier Depot, Beardmore Glacier. Analysts, Burrows and Walkom (1) (p. 207).

3. Micaceous arkose (specimen 9c). Mount Fridtjof Nansen. Analyst, Ellestad.

* Ellestad records a slight, black, insoluble residue, which is undoubtedly carbon.

seven of the 15 specimens contained an average of 99 per cent quartz.

SPECIMENS COLLECTED BY GOULD. Of the total 27 specimens of sedimentary rocks of the Beacon formation collected *in situ* by Gould, 17 were found in the eastern section of Mount Fridtjof Nansen, Queen Maud Mountains, and 10 were collected in the western slope of that mountain. Table 3 records the mineral contents of 17 of the rocks. The constituents of the rocks have an average grain size in thin section of 0.10 mm., in striking contrast to the grain sizes of the minerals in the specimens collected by the British expeditions. The grains vary in outline from angular to subangular, and are well-cemented. Microperthite, hornblende, glauconite (?),

pyrite, and natrolite are absent. Rutile grains and garnet are common, whereas rock pebbles, common in the *Terra Nova* specimens, are absent. Dentated quartz is rare. In fig. 2 are recorded the quantitative measurements of the constituents of seven Mount Fridtjof Nansen specimens all of which are sectioned both parallel and perpendicular to the bedding. The average feldspar content is 45 per

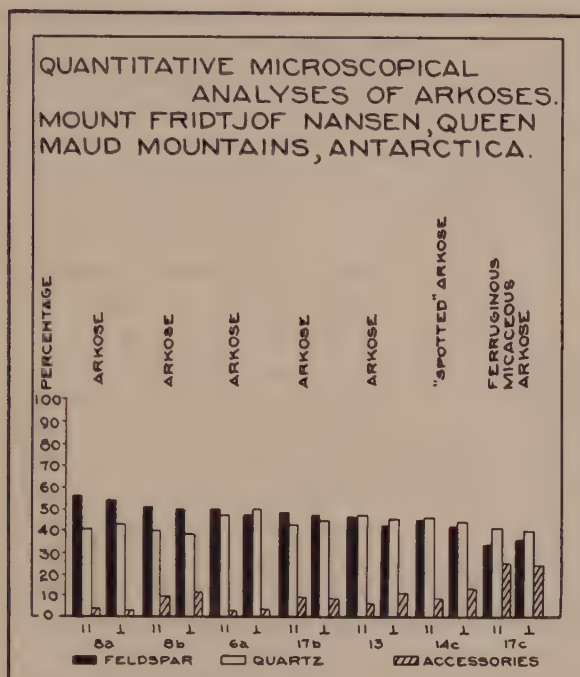


FIG. 2. Quantitative microscopical measurements of sections cut both parallel and perpendicular to the bedding. Gould collection, Mount Fridtjof Nansen, Queen Maud Mountains, Antarctica.

cent in contrast with the much lower feldspar content of the specimens collected by the National Antarctic and *Terra Nova* Expeditions.

CHEMICAL ANALYSIS

Three chemical analyses of sedimentary rocks from the Beacon formation are recorded. Burrows and Walkom (1) (p. 207) have analyzed an arkose from Upper Glacier Depot, Beardmore Glacier, and Ellestad has analyzed an arkose and a micaceous arkose from Mount Fridtjof Nansen.

CONCLUSIONS

The derivation of the material of these sedimentary rocks varied, as did the conditions under which deposition took place. The presence of garnet in practically all of the Mount Fridtjof Nansen slides is an indication that the derivation of the minerals of the sedimentary series was probably from metamorphic rocks, and considering the general mineral content the metamorphic series was acid in character—possibly, intruded by acid igneous types. The presence of such minerals as microperthite and microcline in the specimens collected by the *Terra Nova* Expedition suggests that the source of this material was in granitic rocks. Volcanic fragments, mica schist, chert, and diabase (?) pebbles point to sources varying somewhat from those of the Mount Fridtjof Nansen series. It is possible that the sandstones of the Ferrar Glacier region represent a northern phase of the Queen Maud sediments in that the feldspar content became less as the material was carried farther from the source. Highly feldspathic sandstones have been described by Mawson (1) from the area of the East Fork of Ferrar Glacier. They possibly represent a transition toward the typical arkoses of the Queen Maud Mountains.

It is suggested that the source of the material for the arkoses of the Mount Fridtjof Nansen district was in a great plateau to the south of this area. Undoubtedly, the source would have been in close proximity to the location of deposition, and considering the fact that the British found quite similar arkoses in the Beardmore Glacier district it is possible that the sediments were derived from a land mass to the south made up of acid metamorphic and igneous rocks.

RÉSUMÉ

The Beacon Sandstone formation, composed of great thicknesses of sandstones, arkoses, shales, and beds of low-grade coal, intruded by sills of diabase, rests upon a basement complex of pre-Cambrian age, and extends over a vast area including Adelie, King George V, South Victoria, and Marie Byrd Lands. Fifty-two specimens from the sedimentary strata, collected in South Victoria Land by three Antarctic expeditions, have been examined petrographically. Fine-grained arkoses are recorded from Mount Fridtjof Nansen, Queen Maud Mountains, which extends the known occurrence of the type many miles to the eastward of the Beardmore Glacier area studied by the British. The derivation of the

mineral constituents and the conditions of deposition varied. Two chemical analyses of rocks from the Beacon formation are added to the one already recorded.

ACKNOWLEDGMENTS

To Dr. Laurence M. Gould, geologist of the Byrd Antarctic Expedition, 1928-30, the author is under obligation for the opportunity to study his collection of specimens. Dr. W. Campbell Smith, Curator of the Department of Geology, British Museum of Natural History, very kindly supplied me with duplicate material from the Beacon Sandstone formation collected by the National Antarctic Expedition, 1901-04, and the British Antarctic *Terra Nova* Expedition, 1910-13. Professors William H. Hobbs and Walter F. Hunt, of the University of Michigan, have given most generous cooperation and support to this study.

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LATTICE INDICES AND TRANSFORMATIONS IN THE GNOMONIC PROJECTION

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Technology, Cambridge, Massachusetts.*

ABSTRACT

A single, direct, and self-contained demonstration is given of the important self-indexing characteristic of the gnomonic projection. The demonstration is given first for two dimensions, then generalized to three dimensions. The self-indexing characteristic of the projection is limited to the case in which one of the lattice lines chosen as a crystallographic axis is set normal to the plane of projection. The implied lattice significance of changing the origin, length, and positive sense of units is given; these correspond with changing the direction, length and positive sense of the a axis of the lattice, c remaining fixed. Transformation of indices from one plane of projection to another is discussed. This can be resolved into a change of direction of the lattice a axis plus a change of projection from normal to the c axis to normal to the new a axis. The latter transformation requires an index to be replaced by its negative reciprocal. Goldschmidt's transformation:

$$p_1, \dots, p, \dots, p_2 \rightarrow 0, \dots, \frac{p - p_1}{p_2 - p}, \dots, \infty$$

is then analysed, and shown to be compounded from the above fundamental transformations.

INTRODUCTION

The use of the gnomonic projection in the selection of a coordinate system for a crystal and for the indexing of crystal faces, is well known to those who have had occasion to study crystal surfaces by ordinary optical reflection methods. A rather considerable background is required however, to satisfy one's self, by the usual formal means,^{1,2} that the projection is self-indexing. This is probably its most important crystallographic characteristic. In the present paper an alternative demonstration is given of the self-indexing property, which is simple and direct. A discussion is also given of the significance of changes in coordinates and of Goldschmidt's transformation.

¹ Boeke, H. E., *Die gnomonische Projektion in ihrer Anwendung auf kristallographische Aufgaben*, pp. 22-26, 1913.

² Palache, Charles. *The gnomonic projection*, *Amer. Mineral.*, vol. 5, pp. 77-79, 1920.

SELF-INDEXING PROPERTY OF THE GNOMONIC PROJECTION

TWO-DIMENSIONAL DEMONSTRATION. It will be most simple to demonstrate the indexing in two dimensions and then show that it can be generalized to three dimensions. Figure 1 shows a general, two-dimensional network of lattice points. The plane of projection, AA , is chosen at right angles to some lattice line BC . A lattice origin is established arbitrarily at B . Through this origin, a normal is constructed to each possible lattice line (equivalent to lattice plane, in three dimensions), BE , BF , BG , etc. The gnomonic pro-

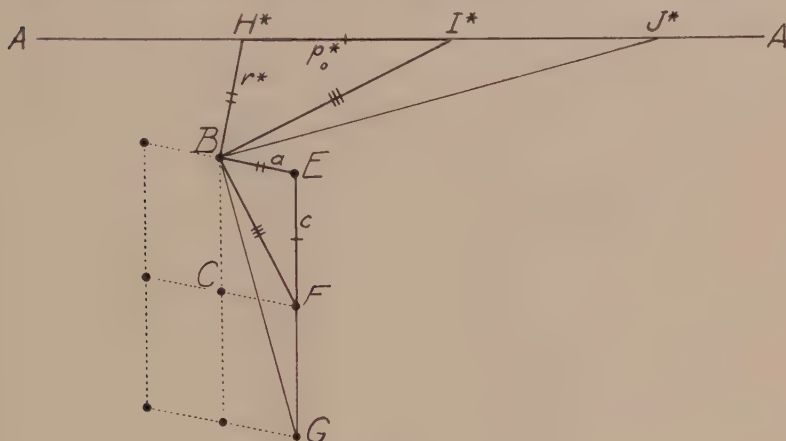


FIG. 1.

jection of the crystal is then the collection of intersections of these normals with the plane of the projection AA .

Suppose $BCEF$ is chosen as the unit cell of the lattice network. The lattice line BE then corresponds to the basal pinacoid, $0(0)1$, the line BF to the unit dome, $1(0)1$, the line BG to the dome, $1(0)\frac{1}{2} = 2(0)1$, etc. (The index number in parenthesis refers to the third lattice axis which does not appear in the present two dimensional demonstration, but which will give convenient comparison in the subsequent generalization to three dimensions.) Triangle BEF has legs at right angles to the homologous parts of triangle BH^*I^* , hence the triangles are similar, and one may write:

$$\frac{H^*I^*}{EF} = \frac{BH^*}{BE} \quad \text{or,} \quad H^*I^* = BH^* \cdot \frac{EF}{BE} = r^* \frac{c}{a}$$

where r^* is the distance of the origin of the gnomonic projection from the lattice origin, and c and a the intercepts of the unit dome on the c and a axes respectively.

For dome $BG = 2(0)1$, triangle BEG is similar to triangle BH^*J^* , from which it follows, as above, that:

$$H^*J^* = r^* \frac{2c}{a}$$

Similar relations hold for other domes. This generalization is conveniently summarized thus:

Plane	Distance from pole of plane to pole of $0(0)1$
$0(0)1$	$r^* \frac{0c}{a} = 0p_0^*$
$1(0)1$	$r^* \frac{1c}{a} = 1p_0^*$
$2(0)1$	$r^* \frac{2c}{a} = 2p_0^*$
$3(0)1$	$r^* \frac{3c}{a} = 3p_0^*$
$p(0)1$	$r^* \frac{nc}{a} = np_0^*$

where p_0^* stands for the constant r^*c/a , which is fixed by the axial ratio c/a and the scale of the projection, r^* . The reason for the asterisk after certain letters will appear in the generalization to three dimensions. p_0^* is established when the basal pinacoid and unit dome are chosen; it is their distance on the projection. The index number corresponding to the a axis for any other plane is then given by the number of p_0^* units in the distance of its pole from the pole of the basal pinacoid. The resulting index is referred to l is unity, i.e.,

$$p(q)1 = \frac{h}{l} \left(\frac{k}{l} \right) \frac{l}{l}$$

This entire relation is based upon the condition that the plane of projection is normal to the lattice line to be chosen as the c axis.

It is void if this condition is not fulfilled, because the above proof depends upon the similarity of two triangles caused by having homologous legs at right angles. Thus, if the plane of projection is imagined slightly tipped from the position shown in fig. 1, the equal p_0^* spaces between the neighboring faces of the series 0, 1, 2, 3 . . . , change enormously toward the right, scarcely at all near the center of the projection.

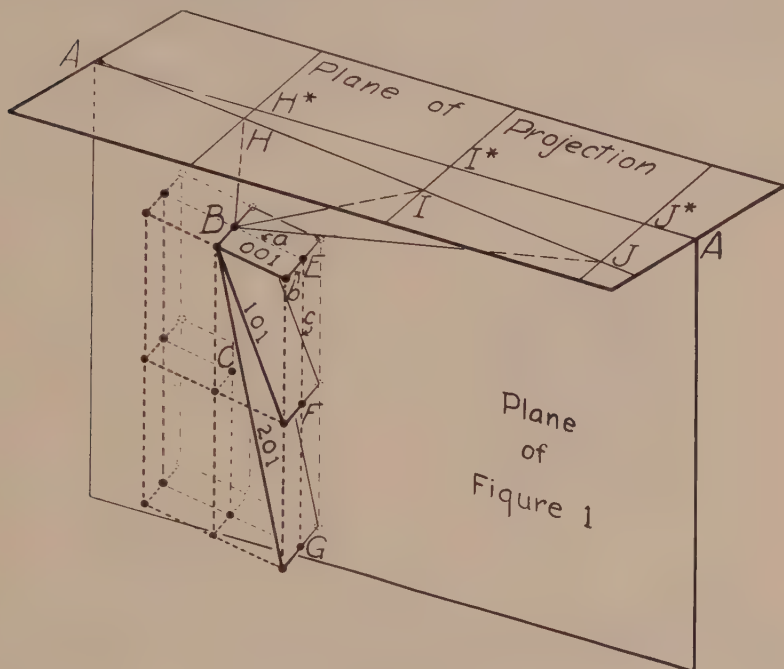


FIG. 2.

THREE-DIMENSIONAL GENERALIZATION. This indexing relationship may now be easily extended to three dimensions. In fig. 2, the plane of fig. 1 is indicated. The lattice is extended beyond this plane in a general manner, after the fashion of a triclinic crystal. The gnomonic projection now consists of the collection of intersections of the normals to lattice planes with the plane of the gnomonic projection. The normal to the basal pinacoid is no longer in the plane of fig. 1, but rather at H . The zone containing the domes, 101, 201, 301 . . . 100, corresponding to the zone discussed for two dimensions, is normal to 100 and $\bar{1}00$, i.e., normal to one of

the sides of the lattice cell, and through the point $H(=001)$. There is a corresponding zone through H running at right angles to the other vertical cell side, 010. These two zones may be regarded as fundamental lines indicating the directions of coordinate axes in the projection.

The locus of the projection of all planes containing the line BE is the last-mentioned zone line, HH^* . In the special case of a plane in this zone normal to the plane of fig. 1, the normal corresponds to the spot H^* , the projection of the basal pinacoid in the two-dimensional discussion. Likewise, the locus of the projection of all planes containing the line BF is a zone line II^* ; in the special case

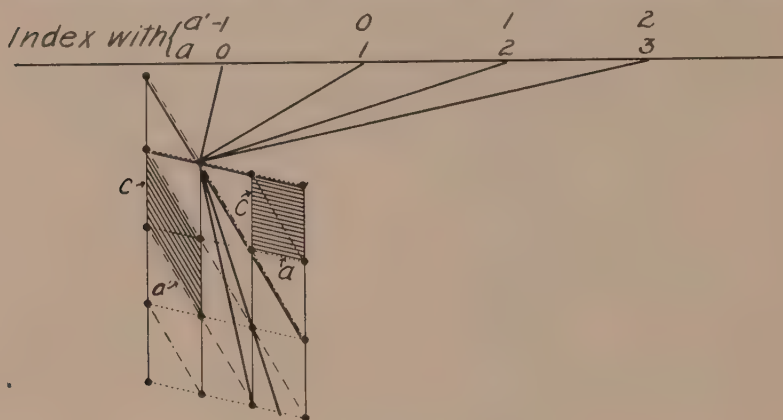


FIG. 3.

of a plane in this zone normal to the plane of fig. 1, the projection point is I^* . Similarly, the projection of any dome is in the same zone as the projection of the corresponding two-dimensional dome. The zone lines just mentioned are all parallel, because they contain the pole of 010 in common, i.e., they are all normal to the 010 plane of the lattice. They are also equally spaced, because they divide the line $H^*I^*J^* \dots$ into equal p_0^* intercepts. It follows that they also divide the line $HIJ \dots$ into equal p_0 intercepts, and that p_0^* and p_0 are related to one another by a proportionality constant. It is not necessary to derive this constant here, the point of the demonstration being that the gnomonic projection is self-indexing in three dimensions just as in two dimensions, once a basal pinacoid and unit dome are selected. The indexing in the remaining dimension follows from a discussion similar to the above.

TRANSFORMATIONS

POSSIBLE FUNDAMENTAL CHANGES. It follows from the preceding discussion that, for a given unit cell, only one indexing of the projection is possible. From a projection point of view, the indexing of a fundamental line (zone) is also fixed if a choice is made of origin, length of unit, and positive direction of unit. It follows that a given choice of these three elements implies a distinct unit cell. The changes in the implied cell for changes in choice of these ele-

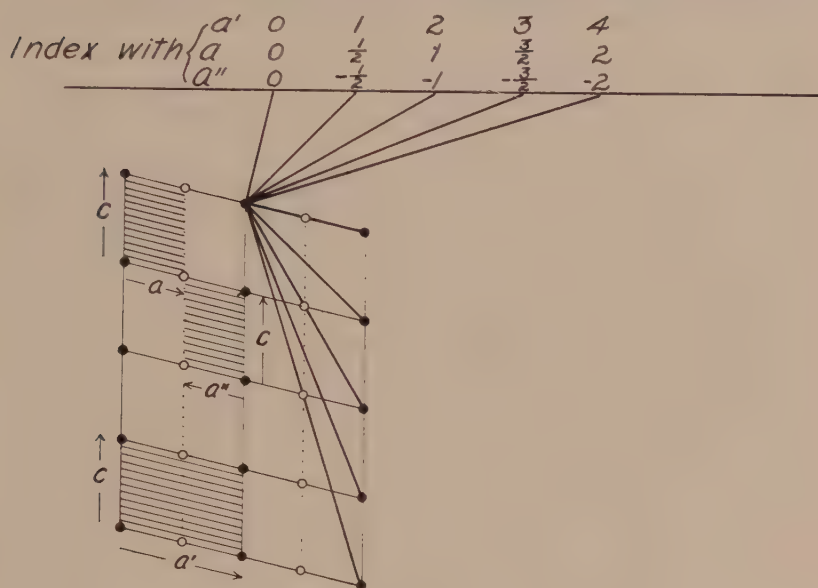


FIG. 4.

ments is most simply followed in a single projection line, corresponding to a two dimensional lattice:

CHANGE OF ORIGIN. Fig. 3 indicates that a shift of origin to $+1$ (i.e., index $p \rightarrow p' - 1$) is equivalent to changing the direction of the a axis of the unit cell so that it is parallel to the direction of the original unit dome. In general, a change of projection origin so that $p \rightarrow p' - n$ implies a shift of a axis direction such that the end of the a translation takes a new position, $-n$ lattice points along the c direction (i.e., n lattice points along the $-c$ direction), the lattice origin remaining undisturbed.

sense) of the a axis, and the length of the a axis remain as possible variables. All of these are included in the above transformations.

CHANGE OF PLANE OF PROJECTION. One other transformation is of importance, namely the change in indexing when the plane of projection is shifted from normal to one lattice line to normal any other desired lattice line. The first lattice line is the c axis according to the designations followed above. The second lattice line is the a axis, or it may be made to become the a axis by the simple expedient of changing the original direction of the a axis to the desired lattice line. This is accomplished by first changing the projection origin through addition of a constant to all indices, as indicated above.

Fundamentally, we require to know how the index, p , of a pole transforms when the plane of projection is changed from normal to the c axis to normal to the a axis, the same unit cell being retained. This can be derived from fig. 5. The index of the pole on the new projection normal to the a axis is designated $-x$. The origins and desired pole are indicated on both projections. In the figure, HZ and BW are parallel, and BH and WV are parallel, because these pairs are normal to pinacoid planes respectively. Also, BY and BZ are identical. Hence triangles VWB and BHZ are similar. This gives the proportion,

$$\frac{-x \cdot x_0}{BW} = \frac{BH}{p \cdot p_0} \quad (1)$$

from which

$$x \cdot x_0 = - \frac{1}{p \cdot p_0} (BW \cdot BH) \quad (2)$$

and

$$x = - \frac{1}{p} \frac{(BW \cdot BH)}{x_0 \cdot p_0} \quad (3)$$

The term in parenthesis is an area dependent upon choice of distances between lattice origin and projection origins, and hence is constant for the transformation. In absolute units, $p \cdot p_0$ transforms directly into its negative reciprocal provided $(BW \cdot BH)$ is chosen equal to unity. For the purpose of indexing, this particular choice of scales is of no importance, for each projection may have its own

scale of x_0 and p_0 units, such that $x_0 = (BW \cdot BH)/p_0$. This makes the last term of the left hand member of (3) equal unity, and p transforms directly into its negative reciprocal. In practice, this is easily arranged by noting that the pole unity transforms into negative unity.

GOLDSCHMIDT'S TRANSFORMATION. In applying the law of complications, Goldschmidt³ found it occasionally desirable to transform the series of indices, $p_1 \cdots p \cdots p_2$, occurring in a zone sequence, to the form $0 \cdots \infty$. This is done by multiplying each of the terms, p , of the series by the constant $p - p_1/p_2 - p$. Goldschmidt only partly justified this transformation, and in any case, the physical significance of each operation of the transformation is lacking. From the transformations just established, Goldschmidt's transformation may be analysed as follows:

(1) To each term, $p_1 \cdots p \cdots p_2$, is added the constant, $-p_2$, giving the series, $p_1 - p_2 \cdots p - p_2 \cdots 0$. Goldschmidt remarks that this is equivalent to shifting the origin of the series. The more fundamental significance is evidently that it is equivalent to choosing a new unit cell of the same volume as the original, but with a different particular position of the cell base. The addition of the particular constant, $-p_2$, to each term, makes the dome corresponding to the original p_2 become the basal pinacoid, with a pole at 0. This transformation is preliminary to changing the plane of projection.

(2) Each of the above terms is inverted giving the series $1/p_1 - p_2 \cdots 1/p - p_2 \cdots \infty$. Goldschmidt justified this on the ground that a series, $0 \cdots \infty$, has the same significance as the series $\infty \cdots 0$. This is not a very satisfying reason. Fundamentally, inversion is equivalent to a permutation of negative a and positive c axial directions in the lattice, which is the same as a shift of the plane of projection from a position normal to the c axis to one normal to the a axis, plus an interchange of positive and negative a axis directions, as shown in a preceding paragraph.

(3) The series is then multiplied by a constant, $p_1 - p_2$, giving the series $1 \cdots p_1 - p_2/p - p_2 \cdots \infty$. Goldschmidt justified this by saying that multiplication by a constant means altering the choice

³ Goldschmidt, V., Ueber Entwicklung der Krystallformen: *Zeit. Krist.*, vol. 28, 1897, pp. 1-35 and 414-451, especially pp. 22-23.

of force units to change the length of the zone. This explanation is, unfortunately, bound up with Goldschmidt's interpretation of the significance of the law of complications. As already demonstrated, the lattice significance of multiplying the designations of the nodes by a constant, $+m$, is that a new unit cell is chosen having the length of the a axis $+m$ times that of the old a axis. In particular, multiplication by $p_1 - p_2$ is equivalent to lengthening the new a axis to stretch the zone from unity to infinity. The last term is already ∞ ; this operation specifically changes the first term to unity.

(4) Finally, a constant 1 is subtracted from each term in order to make the first term zero. The lattice significance of this is the same as in (1), above, namely, a shift of the a axis direction.

Goldschmidt's transformation may be summarized as follows: Any segment of a zone may be stretched to cover the gnomonic projection range 0 to ∞ by an appropriate choice of the plane of projection and an appropriate choice of axes for the unit cell of the lattice. Specifically, a new plane of projection is sought parallel to the normal to one of the two terminal faces of the zone segment; this makes the index of this pole become infinity on the new projection. The other terminal face is made to have the desired index, 0, by multiplying the entire series by a constant, followed by adding a constant; this is equivalent to choosing the new a axis (old c axis) with a new length and a new direction.

A GOLD-BEARING STONY METEORITE FROM MELROSE, NEW MEXICO

H. H. NININGER, *Denver, Colorado.*

The Melrose meteorite, which was first recognized by the writer in February, 1933, evidently represents a very old fall. The $68\frac{1}{2}$ lbs. (31 kgs.) stone which constitutes so far as known, the principal mass of the fall, had been encountered by the plow each season for a number of years. Finally it was hauled away to a ditch and later sought out to be used as a weight on one of the farm implements where it was doing service when its true nature became known.

As the stone reached the laboratory it was rather badly fractured from weathering, and one end had been seriously shattered by a blow from a hammer. The original fusion crust of the stone had all been displaced by oxides of iron, but these oxides nowhere formed a heavy scale except where large metallic inclusions lay immediately below the surface. The surface contour of the meteorite was typical of aerolites—angular, with rounded corners and edges, and noticeable pitting on two sides. It showed no orientation. In weathering, however, the stone showed a tendency to fracture along parallel planes which observed from the outside, suggested a layered structure. Cutting and polishing did not, however, reveal any trace of stratification.

The general color of the stone was somewhat lighter brown than is usually the case with weathered aerolites. This is thought to have been due to its long burial in the soil for the four other stones from this fall which were found later showed the usual dark brown oxide coat. These stones were exposed on the surface when found.

A few months after the first stone was recognized, four other stones weighing respectively: 7021 grams; 5660 grams; 4077 grams, and 3624 grams, were found about 26 miles west of Melrose, near Lalande postoffice. Because of their resemblance to the Melrose stone, these were at once suspected of belonging to the same fall, and a microscopic examination of the polished sections justified such a conclusion even though the distance between the two locations is greater than has ever been recorded for members of the same fall.

The interior of all of these five stones showed, on fresh fracture, a dark brownish gray color with a greenish tinge much like the

McKinney, Texas, stones. Abundant small grains of sulphide were in evidence and in a few cases inclusions of this material were found measuring several mm. in diameter. No nickel-iron could be detected on a surface exposed by fracture; but grinding on a carborundum wheel quickly revealed numerous irregular grains of this alloy.

The large stone was taken to the Nininger Laboratory and some slices removed and polished. An examination of these proved that the stone was to some extent chondritic; but showed no color contrast between the chondri and the ground mass. Nickel-iron was of

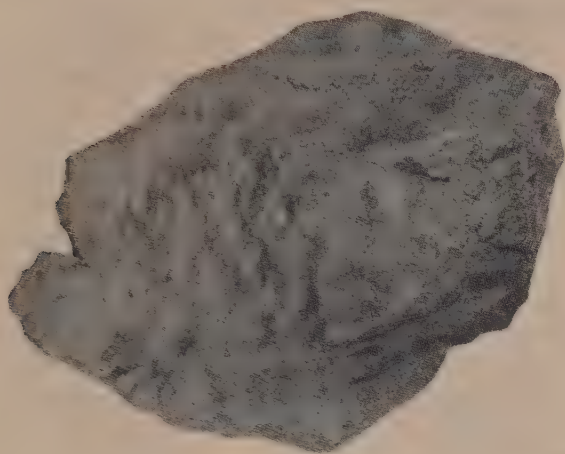


FIG. 1. The Melrose meteorite. Weight $68\frac{1}{2}$ lbs.

ordinary abundance, the grains ranging from minute particles too small to be seen by the unaided eye, up to 7 mm. or 8 mm. in largest dimensions. The sulphide also showed a great range in size of particles. The largest reaching as much as 12 mm. in the greatest diameter. The sulphide grains were frequently found in intimate association with the nickel-iron, sometimes completely surrounded by the latter.

When one of the later-found stones arrived and was cut, it was found to be in a much better state of preservation and the polished surface evidenced characters not visible in the first stone. Distributed through the matrix, according to much the same pattern as is the olivine in pallasites of the Krasnojarsk group, were plainly

seen greenish oval inclusions of this material standing out in rather bold contrast with the surrounding matrix. In other respects the stones appeared similar and a chemical test seemed to confirm their identity as to origin.

The most striking characteristic of this meteorite is its content of gold. In carrying out the usual chemical analysis for stony meteorites, Mr. F. G. Hawley, under date of July 24, 1933, reported as follows: "The generous sample which you sent permitted me to make a good determination for Pt. metals. I think not very many stony meteorites have been tested for Pt. It surprised me somewhat to find so much in a stony meteorite so I made a second assay to be sure there was no mistake.

"Always as a confirmatory test for Pt I dissolve the bead of Pt metals in aqua regia, then concentrate and add stannous chloride which gives a reddish brown color if Pt is present. If gold is present it will give a purple color known as the "Purple of Cassius Test." In all of my previous tests for Pt in meteorites I have obtained only the red-brown color, but this time I got a decided purple tint to the color which apparently indicates that some gold is present with the Pt. If I am correct this is surprising, for I understand that Au has rarely, if ever, been found in meteorites. Also, in dissolving the Pt metals button in aqua regia any iridium or ruthenium will remain insoluble and show up as dark specks of undecomposed residue. Practically always, I have noticed this phenomenon but in this case it dissolved completely with no trace of Ir or Ru (see "Composition and Structure of Meteorites" *U. S. Nat. Museum Bul.* 149, p. 8 footnote).

"I think I am right about the presence of Au; but before certifying it I should like to make two more tests by fire and run them a little differently to separate the gold, if you will send me more material.

"If I find gold is really present I think you should have some other chemist, experienced in this work, check my results so as to leave no doubt in the minds of other scientists regarding its correctness."

The requested sample was sent at once, and on August 15, 1933, Mr. Hawley reported that he had made two more tests which checked exactly, giving .03 oz. Au per ton, and .12 oz. Pt per ton; but stated that the indications were that this second sample was not as rich as the first.

Meanwhile, a sample consisting of many small chips from the shattered portion of the large stone had been submitted to the American Smelting and Refining Company of Denver, for a gold assay. This plant was considered to be in a position to give an extremely accurate assay since no gold samples are handled in the laboratory where the work was done—all gold assays being sent to another plant, hence there would be no danger of accidental "salting." Duplicate tests were run, resulting in .30 oz. and .32 oz. per ton, respectively.

When the later-found stones were sectioned the slush from the saw was saved as nearly complete as possible and sent to Mr. Hawley for another assay. As nearly as could be computed this slush contained about 150 grams of meteoritic dust. The assay again proved that gold was present, and on the basis of our estimate of 150 grams the sample yielded .02 oz. per ton.

In the light of these various assays it is evident that the gold is unequally distributed throughout the meteorite. The chemical analysis by F. G. Hawley was reported as follows:

ANALYSIS OF THE MELROSE METEORITE

Metallic Portion.....0.222 grms.

Analysis

Fe.....	89.1 %
Ni.....	9.2 %
Co.....	1.5 %
Cu.....	0.02%

Non-Metallic Portion.....49.6 grms.

Analysis

FeO.....	16.13%
Fe ₂ O ₃	12.03%
NiO.....	1.23%
CoO.....	0.08%
Cr ₂ O ₃	0.56%
Al ₂ O ₃	2.20%
TiO ₂	0.12%
MnO.....	0.29%
CaO.....	2.35%
MgO.....	22.15%
K ₂ O.....	0.08%
Na ₂ O.....	0.29%
SiO ₂	35.90%
SO ₃	0.35%
Cl.....	0.06%

P_2O_5	0.22%
FeS.....	4.95%
H_2O	1.16%

 100.15

Pt. metals..... 0.24 oz. per ton.

Gold Assays on the Melrose Meteorite. All made in Duplicate.

No. 1. F. G. Hawley 0.03 oz. per ton.

No. 2. F. G. Hawley 0.02 oz. per ton.

No. 3. American Smelting & Refining

Company 0.30 and 0.32 oz. per ton.

A petrographic examination of the Melrose stone is being made by W. A. Waldschmidt of the Colorado School of Mines and will be reported upon later by that investigator.

NOTES ON THE SYNTHETIC RESIN HYRAX

EUGENE N. CAMERON, *New York University.*

For many years Canada balsam has been the standard mounting medium for most mineralogical and petrographical material, because of its stability, clarity, and ease of preparation, and because its index of refraction is convenient for many purposes. There are certain purposes, however, for which a resin of higher index could be employed to advantage in work of this kind. The purpose of this paper is to discuss the properties of one such resin, hyrax; the methods of preparing mounts with the resin; and several of its possible applications in mineralogy and petrography.

The author is indebted to the Department of Mineralogy of Columbia University for furnishing the facilities and most of the material for the work here described. He also wishes to express his gratitude to Dr. Paul F. Kerr, of Columbia, for many suggestions and much constructive criticism, and for a critical reading of the manuscript. Mr. Paul H. Bird, of the same institution, has also made a number of helpful suggestions, based on his experience in making thin sections.

PROPERTIES OF HYRAX

Hyrax is the result of a search initiated by G. D. Hanna (1) for a satisfactory high-index mounting medium for diatoms. It is a synthetic resin, a stable derivative of naphthalene soluble in toluol, xylol, benzol, and a number of other organic solvents, but not in alcohol or in water. When pure it is a transparent, brittle, amorphous solid, straw yellow in bulk but almost colorless in thin films. It is permeable to the blue and violet rays, important in photography (2). Slides kept by Hanna (2) from 1926 to 1930 showed no decomposition or alteration, although there was a slight darkening, comparable to that observed in old balsam slides, in hyrax slides left exposed to light.

Hyrax is obtainable from the manufacturers¹ either in solid form or dissolved in toluol. The dissolved resin has an index of refraction of about 1.65, but the index increases as the solvent is evaporated and reaches a maximum with complete removal of the solvent.

¹ Penn and Ruedrich, Box 26, Associated, Cal. Eastern agent: Eimer and Amend, *New York City*, N.Y.

There has been considerable disagreement as to the exact value of this upper limit. The various values reported range from 1.70 to 1.825.

For petrographic and mineralogic work, it is essential that the mounting medium used be of known, constant index of refraction; for the identification of imbedded minerals is commonly based partly on their indices referred to the index of the medium. For this reason the author felt it necessary to make a careful re-determination of the index of pure hyrax, with due regard to possible sources of error.

The variations in the reported results may be due, in different cases, to any one of the following causes:

- (1) Instability of the resin, with resultant inconstancy of index.
- (2) Failure to evaporate the solvent completely from dissolved hyrax.
- (3) Use of different wave-lengths of light by different observers.
- (4) Unreliability of the method of determination used.
- (5) Mechanical error.

The resin has not been proved to be perfectly stable, but according to Hanna (1) no indication to the contrary has appeared. The slides of mineral fragments mentioned below confirm this statement. Failure to evaporate the solvent completely from dissolved hyrax was avoided by the writer by using the pure, solid resin to mold the prism required for the determination. Certain of the higher values reported for the index of refraction of hyrax were obtained in violet or ultra-violet light. Since most microscopic and photomicrographic work is done in ordinary light, the present determination was made in sodium light, as giving a value approximating that obtained by the method of central illumination in ordinary light.

The prism method of determination was used. In order to reduce mechanical error to a minimum, an average of five separate determinations was taken, giving a value of $n=1.7135$. As a rough check on the accuracy of the determination and the constancy of the material, the author has also prepared numerous slides of minerals ranging in their indices of refraction from 1.68 to 1.76.

PREPARATION OF MOUNTS WITH HYRAX

If dissolved hyrax is used, it should be further diluted with one part of toluol to three parts of hyrax, by volume, otherwise bubbles are apt to form during cooking. The time necessary to remove

the solvent varies with the temperature at which it is evaporated and with the depth of the resin in the cooking vessel. Thin films cooked on slide glasses require one hour at 100° Centigrade.

The preparation of thin sections has been described by H. G. Fisk (4). If this procedure is followed, the long period of cooking mentioned by him may be avoided by obtaining solid hyrax.

Hyrax has a higher surface tension than has balsam; hence bubbles are somewhat more difficult to avoid in preparing slides with the former resin. This is particularly true in making slides of mineral grains (or fragments), for it is not possible to squeeze all bubbles from such a slide by gentle pressure on the cover glass while the slide is cooling. The writer has found that a few bubbles must be expected in most slides of this type. If the method described below is followed carefully, these will be not only few in number but also extremely minute, unattached to the mineral grains, and in no way detrimental to the usefulness of the slide.

In making mounts of mineral fragments with Canada balsam the practice is first to cook the resin on the slide and then to place the fragments in the resin. If this procedure is followed with hyrax many of the fragments remain on the surface of the resin, and bubbles form. In making mounts with hyrax, therefore, the fragments should be scattered on the slide glass first, and the resin, previously diluted as described above, should then be poured over the fragments in sufficient amount to form a patch somewhat larger than the cover glass to be used. The slide should next be placed on the heating unit, cooked for one hour at 100° Centigrade, and then removed. At this point the slide should be free from bubbles. Stirring the fragments must not be resorted to at any stage, or bubbles will appear which subsequent cooking will not eliminate; moreover, gentle pressure on the cover glass while the slide is cooling will secure a satisfactory distribution of the grains. The only bubbles which cannot be eliminated from the mounts are those which usually appear when the cover glass is placed on the slide. These may be reduced to a minimum by resting one edge of the cover glass on the slide, just within the boundary of the patch of hyrax, and allowing the cover glass to drop slowly and evenly. During this operation the heating unit should be kept at a temperature of 120° Centigrade.

APPLICATIONS OF HYRAX

In general, the high index of refraction of hyrax makes it useful:

- (1) For increasing the relief of minerals which have indices of refraction close to that of balsam.
- (2) For decreasing the relief of minerals which have indices of refraction too much above that of balsam.
- (3) For facilitating the identification of certain minerals.

The cleavage, form, and fracture of grains of minerals whose indices lie close to that of balsam are not clearly visible, but merely suggested by the outlines of the grains. In hyrax these features are clearly distinguishable; and as they often give clues to the identities of the minerals, or to the processes which the grains have undergone, hyrax can be used to advantage for permanent mounts of grains of these minerals (cf. Pl. I, Figs. 1 and 2).

Since most sandstones and sands are composed largely of quartz grains, in any study of the grains composing such rocks, with the purpose of determining, from the shapes of the grains, the agents responsible for their transportation and deposition, it is better to mount the grains in hyrax, in which not only the outline but also every detail of the shape of each quartz grain is revealed.

In the photomicrography of mineral grains the difference between the refractive indices of mineral and mounting medium (i.e., the relief) has an important bearing on the results obtained. If the relief is too low, the grains appear on the plate as mere outlines. If the relief is too high, those portions of the surfaces of the grains which are not parallel to the plane of the stage of the microscope become, due to internal total reflection, too deeply shadowed, so that the peripheries of the grains appear in the photomicrograph only as dark rings.

The photomicrographs of mineral grains reproduced in Plate I illustrate the results obtained with varying degrees of relief. The index of refraction of quartz is very near that of balsam; hence the shapes of quartz fragments mounted in balsam (Fig. 1) are not clearly visible. Increasing the relief by mounting the fragments in hyrax (Fig. 2) gave greater visibility. On the other hand, the index of refraction of corundum is so much higher than the index of balsam that the peripheries of fragments of the mineral mounted in balsam (Fig. 3) are dark, while in some cases entire grains appear deeply shadowed. Fragments of the same mineral mounted in hyrax (Fig. 4) have relief sufficient to bring out the details of the shapes of the fragments, but the dark borders are reduced in width. Grains of monazite in balsam (Fig. 5) show a similar contrast to grains of the same mineral mounted in hyrax (Fig. 6).

PLATE I

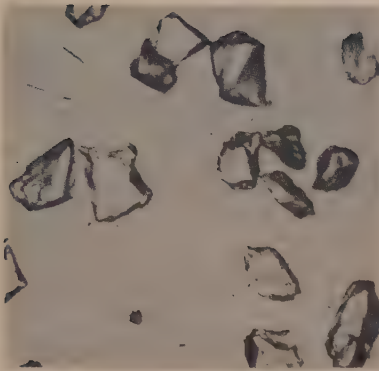


FIG. 1. Quartz fragments in balsam.
Average relief = .009.

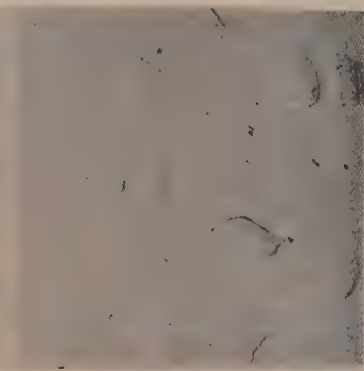


FIG. 2. Quartz fragments in hyrax.
Average relief = .165.



FIG. 3. Corundum fragments in balsam. Average relief = .225.

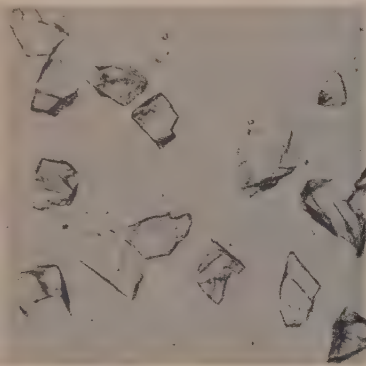


FIG. 4. Corundum fragments in hyrax.
Average relief = .051.

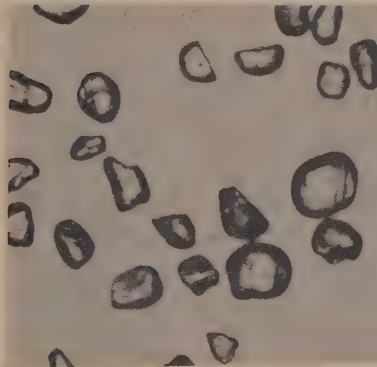


FIG. 5. Monazite sand in balsam. Average relief = .280.

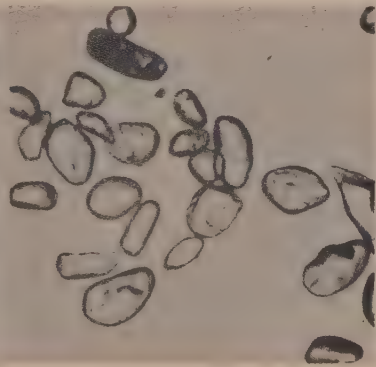


FIG. 6. Monazite sand in hyrax. Average relief = .112.

A series of photomicrographs taken for the purpose of determining the proper relief shows that good results are obtained when relief lies between .040 and .140. In general, too much relief is better than too little. Definition appears to be best when relief lies between .040 and .070. In the case of a given mineral, its refractive index will indicate whether balsam or hyrax is to be preferred as a mounting material.

The identification of the various members of a mineral assemblage is aided if it is possible to split the assemblage into two groups, relative to the index of refraction of the medium in which the minerals are mounted. An example of this is the convenient position of the index of balsam among the indices of the feldspars. If the indices of all, or nearly all, the members of an assemblage lie above (or lie below) the index of the imbedding medium, the indices of the members are of little value, except in so far as relief can be estimated, which is at best a doubtful procedure. For a given assemblage, therefore, the material which divides the assemblage most nearly into two equal groups is to be preferred as a mounting medium.

In view of this fact, it appears that hyrax should be useful as a permanent mounting medium for a number of different heavy mineral assemblages. The following list of minerals most commonly occurring in heavy mineral residues is adapted from Milner (5). The two indices given for each (except leucoxene and fluorite) represent the minimum and maximum indices, respectively, which the species may show (6 and 7) and therefore represent the limits of the range of indices for the particular species. The minerals are here arranged in two groups, relative to the index of hyrax; hence certain of the species appear in both parts of the table. In each part the minerals are listed in order of increasing minimum index of refraction.

Of the 31 mineral species given in the table, only 3 (fluorite, aragonite, and biotite) may have indices of refraction below that of balsam (n = about 1.54), while 19 may have one or more indices below the index of hyrax and 17 may have one or more indices above the index of hyrax. Inclusion of the less common heavy minerals would not change the proportions materially; hence the index of hyrax, which enables division of the group into two nearly equal parts, should make the resin more suitable than balsam as a permanent mountant for such residues.

In a thin section of a given rock, the visibility of the microstructures of the rock, and of the internal structures and mutual relations of the component mineral grains is to some extent dependent on the relief between the minerals of the rock and the material in which the section is mounted. Thus, it sometimes happens that features of this kind which are obscure in sections mounted in balsam are more clearly defined in sections mounted in hyrax.

TABLE I.—DISTRIBUTION OF MINERALS WITH REFERENCE TO HYRAX AS THE MOUNTING MEDIUM

1 or >1 index < <i>n</i> hyrax		1 or >1 index > <i>n</i> hyrax	
Mineral	Indices	Mineral	Indices
Fluorite	1.434	Smithsonite	1.621–1.849
Aragonite	1.530–1.685	Siderite	1.633–1.875
Biotite	1.535–1.690	Augite	1.712–1.733
Tremolite	1.599–1.624	Spinel	1.713–1.726
Tourmaline	1.620–1.690	Cyanite	1.713–1.729
Glaucophane	1.621–1.639	Epidote	1.729–1.780
Smithsonite	1.621–1.849	Grossularite	1.730–1.735
Andalusite	1.629–1.647	Staurolite	1.736–1.746
Apatite	1.629–1.648	Corundum	1.760–1.769
Siderite	1.633–1.875	Monazite	1.800–1.849
Barite	1.636–1.648	Titanite	1.888–2.008
Enstatite	1.656–1.671	Zircon	1.927–1.982
Sillimanite	1.657–1.684	Cassiterite	1.996–2.093
Hornblende	1.658–1.701	Chromite	2.069–2.160
Hypersthene	1.692–1.705	Octahedrite	2.487–2.564
Zoisite	1.696–1.706	Rutile	2.567–2.981
Augite	1.712–1.733	Leucoxene	high
Spinel	1.713–1.726		
Cyanite	1.713–1.729		

In such cases the latter resin is useful for purposes of microscopic study or of photomicrography.

For example, a better contrast between quartz and orthoclase in an intergrowth of the two minerals is obtained in a thin section mounted in hyrax (Pl. II, Fig. 2) than in a section of the same intergrowth mounted in balsam (Pl. II, Fig. 1). Consequently, the relations between the two minerals are more clearly shown in the former. The cleavage of the feldspar and the fractures in the quartz are also more prominent in the section mounted in hyrax. In this case improvement was obtained by increasing relief.

PLATE II

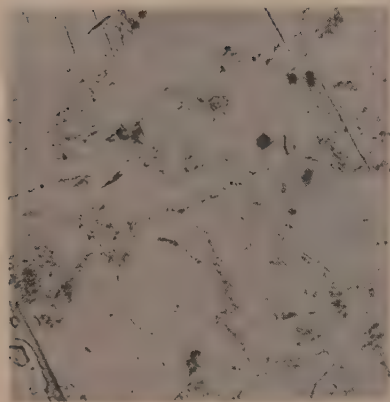


FIG. 1. Section of an intergrowth of quartz and orthoclase mounted in Canada balsam.

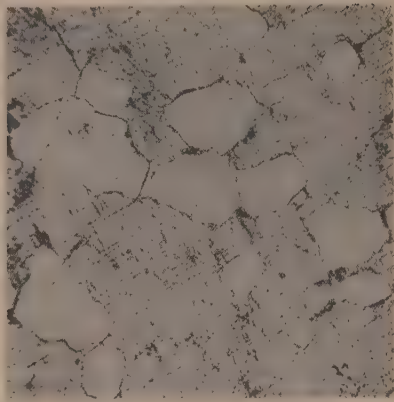


FIG. 2. Section of the same intergrowth of quartz and orthoclase, mounted in hyrax.

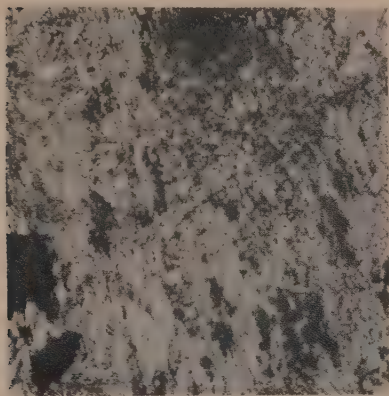


FIG. 3. Section of an aggregate of amphibole, mounted in Canada balsam.

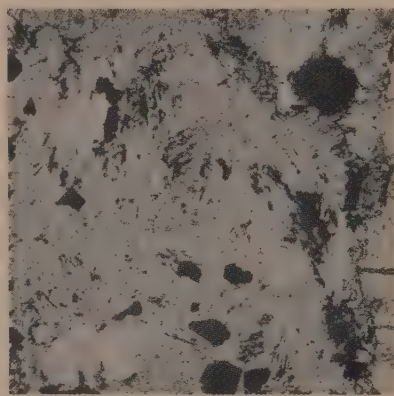


FIG. 4. Section of a similar aggregate of amphibole, mounted in hyrax.

On the other hand, certain kinds of structures are more clearly defined in thin sections when relief between the minerals concerned and the mounting material used is low. In cases of this sort in which the indices of refraction of the minerals (or mineral) involved lie closer to the index of hyrax than to the index of balsam, the

former resin is the more satisfactory mounting material. The aggregate of amphibole replacing an earlier ferromagnesian shown in Fig. 3 (section in balsam), and in Fig. 4 (section in hyrax) of Plate II is an example of this type of structure. The relief of the aggregate is too high in balsam; hence the structure is confused in the section mounted in this resin. In hyrax the relief is much less, and the details of the structure are more clearly resolved.

The applications of hyrax discussed above are not presented as an exhaustive list of its possibilities, but they serve to indicate its potential usefulness in mineralogy and petrography. Numerous other purposes for which it is satisfactory will doubtless be discovered from time to time.

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NOTES AND NEWS

A MOUNTING MEDIUM OF 1.66 INDEX OF REFRACTION

W. D. KELLER, *University of Missouri.*

The writer wishes to call attention to the use of a synthetic resin having an index of refraction of about 1.66 which is suitable as a mounting medium for thin sections and mineral powders.

The index of refraction being moderately high makes the material more desirable than Canada balsam for mounting the heavy minerals of sandstones. Those minerals usually have high indices of refraction and show excessively high relief in balsam but are more nearly matched in the resin described.

A particularly advantageous use of this medium is in mounting high alumina refractory materials which contain in the fired state both mullite and corundum. Corundum has indices of refraction of about 1.760, considerably above that of the resin, whereas mullite just about matches or is below the resin in index. It is obvious that differentiation between the two, and quantitative estimation of the amounts of each is greatly facilitated by the slide or powder being mounted in a medium having an index of the value given, 1.66. Dispersion is not high.

The resin is clear in thin section but light honey yellow in a larger quantity. It is solid, or rather a very viscous liquid, about like pitch, at ordinary temperature. It becomes sensibly fluid, "melts," at about 70°C. without bubbling and does not darken with heating. No objectionable odor is connected with the material. It is soluble in xylol which is used to clean the finished slides. The resin is strong, not particularly brittle, and has not shown granulation nor deterioration after a half year's use in the laboratory. That time is too brief, of course, to judge its durability, but it has proven satisfactory so far.

The writer was advised of the availability and utility of this material by Mr. R. S. Bradley of the A. P. Green Firebrick Co., who in turn learned of it from Mr. Kraner of the Corhart Refractories Co.

The resin is sold by the Swann Chemical Co., Anniston, Alabama, under the name *Aroclor No. 4456*, and lists at \$0.40 per pound, a price that is not excessive for mounting media.

RECENT DEVELOPMENTS IN HIGH INDEX RESINS

A. E. ALEXANDER, *Buffalo, New York.*

Petrographers interested in the mounting of heavy and accessory minerals have had varying success with high index immersion media.¹ None developed to date have been entirely satisfactory.

Attention should be called to several high index resins recently developed by Mr. J. T. Rooney, chemist, of Buffalo, New York. The writer has had the privilege to test these resins thoroughly and has found them to be clear and to possess good color. Once melted, the resins do not have to be cooked. They harden upon cooling much faster than Canada balsam, yet they will not crack. The resins can be obtained in the following indices: 1.60, 1.61, 1.62, 1.63, 1.64, and 1.65.

Petrographers can purchase these resins from Mr. Rooney, at the following address: Inspection and Research Laboratories, 52 West Chippewa Street, Buffalo, New York.

¹ Martens, J. H. C., Piperine as an Immersion Medium in Sedimentary Petrography: *Am. Min.*, vol. 17, No. 5, May, 1932.

FIBROUS PYRITE FROM THE LEAD-ZINC DISTRICT OF ILLINOIS

KENDALL E. BORN, *Washington University.*

INTRODUCTION

Marcasite has been recognized by Bain¹ and other workers as an abundant gangue mineral in the lead and zinc deposits of southwestern Wisconsin and adjoining parts of Illinois and Iowa. Pyrite has also been recognized and described, but it has been considered less abundant than marcasite. The two iron sulphides are intimately associated with the galena and sphalerite which occur as crevice and fissure fillings in the Galena dolomite of Ordovician age.

The present paper describes pyrite with a distinctly fibrous structure and suggests that this mineral is far more abundant than hitherto recognized. The specimens which form the basis for these conclusions were collected from the Eadie Mine, near Hanover, Illinois, and the Blackjack Mine, about 3 miles south of Galena,

¹ Bain, H. F., Zinc and Lead Deposits of the Upper Mississippi Valley: *U. S. Geol. Survey, Bull.* 294, p. 49, 1906.

Illinois, and are now in the mineral collections of the Department of Geology and Geography, Washington University.

Professor O. R. Grawe of the School of Mines and Metallurgy, University of Missouri, first noted the true nature of this material. The specimens were referred to the writer for further study and investigation by Professor W. D. Shipton, Department of Geology and Geography, Washington University. Professors Grawe, Shipton, and Charles H. Behre, Jr. of the Department of Geology and Geography, Northwestern University, have read the manuscript and their suggestions and criticisms are gratefully acknowledged.

IDENTIFICATION OF THE PYRITE

Many methods of distinguishing pyrite from marcasite have been suggested. Stokes² proposed a chemical method based upon oxidation, and Allen, Crenshaw, Johnston, and Larsen³ have recorded a detailed treatment of the iron sulphides. More recently α -rays have been employed with excellent results in the differentiation of these two sulphides of iron.⁴

Several polished sections of the fibrous mineral from the Eadie Mine were made by the writer for study. Each polished section was definitely isotropic and in only one section was a possible intergrowth of the pyrite and marcasite suggested. Weakly anisotropic pyrite has been reported, but according to Bannister,⁵ it may be clearly distinguished from the distinctly anisotropic character of marcasite.

A series of specific gravity determinations by the pycnometer method ranged from 4.97–5.14. When boiled in a weak (3 per cent) solution of silver nitrate, the mineral was tarnished a light brown in color; this color persisted. Marcasite tarnished brown, then red, and finally blue under the same conditions.⁶ The nitric acid test

² Stokes, H. N., On Pyrite and Marcasite: *U. S. Geol. Survey, Bull.* **186**, 1901.

³ Allen, E. T., Crenshaw, J. L., Johnston, John and Larsen, E. S., The Mineral Sulphides of Iron: *Am. Jour. Science*, vol. **33**, pp. 169–236, 1912.

⁴ Bannister, F. A., The Distinction of Pyrite from Marcasite in Nodular Growths: *Mineralogical Mag.*, vol. **23**, pp. 179–187, Sept., 1932.

Van Horn, F. R., and Van Horn, K. R., X-ray Study of Pyrite or Marcasite Concretions in the Rocks of the Cleveland, Ohio, Quadrangles: *Amer. Mineralogist*, vol. **18**, No. 7, pp. 288–294, 1933.

⁵ *Op. cit.*, p. 186.

⁶ Dana, E. S., and Ford, W. E., A Textbook of Mineralogy (4th Ed.): John Wiley & Sons, New York, p. 438, 1932.

gave very little free sulphur after warming. Marcasite characteristically gives abundant free sulphur when the mineral is dissolved in nitric acid.

DESCRIPTION OF THE PYRITE

Most of the specimens of iron sulphide from the Eadie Mine, a very shallow working, display a radiating fibrous structure, some show a distinctly bladed structure and gradations of these two types are very common. In this respect, as well as its light silvery color, the mineral strongly suggests marcasite. A gradation from cubic crystals through a more or less bladed structure to a definitely fibrous structure was noted in one of the specimens (Fig. 1). Greater elongation of the faces of the cube in one direction explains this fibrous appearance. Small individual cubes modified by the octahedron and pyritohedron were noted on several specimens of the fibrous pyrite.

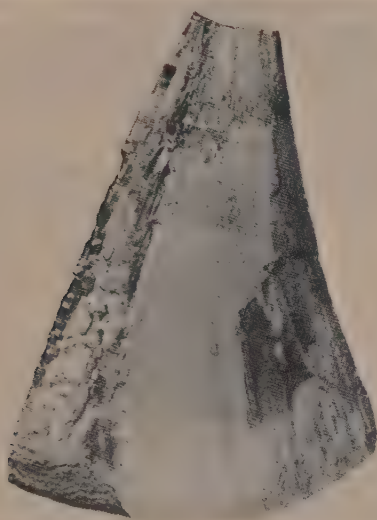


FIG. 1. Specimen of pyrite showing the gradation from cubic crystals into a distinctly fibrous structure. From the Eadie Mine, near Hanover, Illinois. About $\frac{2}{3}$ natural size. (Photograph by O. R. Grawe.)

One specimen from the Blackjack Mine was composed of a group of roughly symmetrically developed cubes made up of columnar in-

dividuals in a radial arrangement about a common center. Hobbs⁷ observed this form of pyrite in the Galena district as early as 1895. He described cubes of pyrite developed in the direction of one of the principal axes and concluded that "the large radial sheaves of iron sulphide which occur at Galena are for the most part pyrite." However, since specimens showing this columnar development of the cube are not common in the lead and zinc region of the Upper Mississippi Valley, it appears that much of the fibrous iron sulphide has been referred to as marcasite. Van Horn⁸ has stated that acicular iron sulphides have been termed marcasite, probably upon the basis that an orthorhombic mineral might assume this habit more readily than an isometric mineral.

SUMMARY

The present study points to the fact that some of the fibrous iron sulphide found in the lead-zinc district of the Upper Mississippi Valley has been erroneously termed marcasite. Marcasite has been reported to be the most abundant iron sulphide in the area. While this contention may be correct, it seems logical to raise the question whether the amount of pyrite present has not been greatly underestimated.

⁷ Hobbs, W. H., A Contribution to the Mineralogy of Wisconsin: *Univ. of Wisconsin Bull., Science Series*, vol. 1, No. 4, p. 145, 1895.

⁸ *Op. cit.*, p. 288.

BOOK REVIEW

THE PETROGRAPHY OF THE KOLA PENINSULA (In Russian), B. M. KUPLETSKI. Academy of Sciences, U.S.S.R., Petrographical Institute, Leningrad, 1932; Series I. Regional Petrography. Six roubles.

In addition to the text proper consisting of 150 pages the book contains a geological map of the Kola Peninsula, 184 new analyses of minerals and rocks, and a few smaller sketch maps. The emphasis is not placed so much on the well-known apatite and nepheline deposits as in former papers, but the general geology, glacial phases excepted, is presented in a more unified manner and with greater completeness than hitherto.

The Kola Peninsula lies north of the White Sea, and is a prolongation, in rocks and structure, of the Fennoscandian Archean region. It is a horst bounded by a disconnected rim of downfaulted early Paleozoic sediments. Most of the peninsula is formed of pre-Cambrian schists and gneisses, once sediments, and include a wide variety. Among the early Archean ones are grünerite, actinolite, and magnetite schists, the last so rich in magnetite as to be a prospective iron ore. Into these are intruded an early Archean granite, now gneissic and somewhat crushed, and a late

Archean rapakivi with coarse texture and large phenocrysts. Two large outcrops of alkaline granite in the east half of the peninsula contain crossite and aegirine for their mafic minerals.

There are many intrusions of basic rocks, also of two ages. The older ones are the oldest known intrusives here: the metamorphosed gabbros and pyroxenites at the head of Kandalaksha Bay. The later ones, of possible Cambro-Silurian age, are fresh and more widespread. Two 70-foot sills are found, with enstatite and olivine segregated at the bottom, fine-grained labradorite in the middle, and coarse labradorite at the top.

One chapter is devoted to a description of the many and varied dikes of the Turya Cape. Another includes the other alkaline rocks: natrolite syenite dikes of the northern region, shonkinite dikes of the western, and most important, the two great masses of the west central part. The western one of these two masses has, excluding the endocontact rocks, a very coarse border of hibinite with 35% of nepheline. Inside this is a series of fine-grained nepheline syenites, and at the core is a coarse foyaite with 20% of nepheline. In tabular masses within the southwest part of the hibinite occur the economically valuable rocks: urtite with 80–90% of nepheline, and an apatite rock with 60–85% of apatite. The urtite is to be used as an ore of aluminum, and the apatite is being quarried for phosphate from a billion-ton deposit. Kupletski favors Bowen's or Smyth's hypothesis in explaining the genesis of these rocks, but does not discuss the question at length. The eastern mass is somewhat similar, with local sodalite, eudialyte, and cancrinite syenites.

The sedimentary rocks around the rim include sandstones (some glauconitic) and shales, non-fossiliferous and possibly of Silurian age.

Besides nepheline and apatite, economically useful materials include magnetite, diatomite, ores of copper and nickel, and many less abundant ones. Extensive nepheline sands near the main alkaline mass are being used for glass manufacture.

The mineral assemblages of the Hibina Tundra nepheline rocks include many unique and beautiful minerals. Their description and a discussion of the geochemistry of the rocks is given by Fersman in this journal, volume 11 (1926), pages 289–299.

CHARLES D. CAMPBELL

PROCEEDINGS OF SOCIETIES

MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

MINERALOGICAL SOCIETY, June 7, 1934, SIR THOMAS J. HOLLAND, President, in the chair. PROF. C. PALACHE: *The form relations of the lead oxychlorides, laurionite, paralaurionite, and fiedlerite.* The separate identity of each of the first two minerals is confirmed and their homoeomorphism is exhibited by a re-orientation of laurionite. The form series of fiedlerite has been simplified by the choice of a new unit form. New forms are described on paralaurionite and fiedlerite. The crystallography of all three species is summarized in new angle tables, and their habits are illustrated by a series of drawings.

MR. F. A. BANNISTER: *The crystal-structure and optical properties of mallockite (PbFCl).* W. Nieuwenkamp's recent work proving the identity of mallockite with artificial lead fluochloride PbFCl has been confirmed. New chemical analyses,

x-ray work and optical measurements have been carried out on single crystals of matlockite from Cromford, Derbyshire. Single crystal photographs of the mineral have also confirmed the crystal-structure proposed for artificial PbFCl . Artificial BiOCl , BiOBr and BiOI have crystal-structures of the same type and the relationship between matlockite and these and other compounds is discussed. Artificial Pb_2OCl_2 has a crystal-structure quite different from that of matlockite. Mendipite, $\text{Pb}_3\text{O}_2\text{Cl}_2$ contains no fluorine and it is improbable that fluorine has been overlooked in the oxychloride minerals from Laurium, Greece.

DR. V. ZSIVNY and DR. L. ZOMBORY: *Berthierite from Kisbánya, Carpathians*. This rare mineral, previously known from two localities in old Hungary, is now described from a third, namely Kisbánya in comitat Szatmár (now Chiuzbaia in Satu Mare, Romania) where it occurs as bundles of needles with stibnite and rhombohedral carbonates. Analysis agrees closely with the formula $\text{FeS} \cdot \text{Sb}_2\text{S}_3$, but the specific gravity 4.65 is much higher than values previously recorded.

DR. L. J. SPENCER: *Beryllium minerals (euclase and phenakite) from Africa*. Apart from beryl, there are very few recorded occurrences of beryllium minerals in the whole of Africa. Euclase is described from pegmatite on the Lukangasi mica claim, Morogoro district, Tanganyika Territory. The main crystal on the single specimen collected measures 7.2 by 3.5 cm., being much larger than any euclase crystal hitherto known. Seventeen crystal-forms were determined. Small crystals of phenakite from pegmatite at the Klein Spitzkopje, South-West Africa, are of two distinct habits, prismatic and lenticular.

MR. A. C. SKERL and MR. F. A. BANNISTER: *Lusakite, a cobalt-bearing silicate from Northern Rhodesia*. The mineral occurs embedded in quartz-magnetite-kyanite-rock of gneissoid appearance from 80 miles east of Lusaka. Crystals, generally tabular to (010) varying up to 5 mm. in length, are black in hand-specimens, but show a deep cobalt-blue colour, and strong pleochroism in thin section. The mean refractive index is approximately 1.74 and $2V$ is near 90° . Oscillation, Laue, and rotation photographs show that lusakite has an orthorhombic unit cell with edges $a=7.86$, $b=16.62$, $c=5.63$ Å., and space-group V_h^{17} . The unit cell contains 8 $(\text{RO} \cdot \text{Al}_2\text{SiO}_5)$ where R represents Fe, Co, Ni, Mg, Al, and H. The cobalt content is unique for a silicate and reaches $8\frac{1}{2}\%$ CoO or nearly two atoms of cobalt per unit cell. It is almost identical in physical properties with staurolite and x-ray photographs show that it possesses the same type of crystal-structure.

DR. A. W. GROVES: *The determination of small amounts of copper in rocks*. The paper describes the application to silicate analysis of the sodium diethyl-dithiocarbamate colorimetric method for copper. Data on the retention of copper by the ammonia precipitate are given. The method has a range of about 0.001% to 0.25 per cent. CuO when a sample of 2 grams is used.

DR. L. J. SPENCER: *Thirteenth list of new mineral names*. A dictionary list of 112 names collected from the literature of the past three years. Since the first list in 1897 a total of 1918 names has been collected.

DR. L. J. SPENCER: *A new meteoric stone from Silvertown, New South Wales*. A beautifully oriented stone weighing 351 grams was found by Mr. R. Bedford amongst debris in the old museum at Port Adelaide, which has recently been reorganized as a Nautical Museum. It probably dates from the time (1883) of the discovery of the rich mineral deposits at Broken Hill in the Silvertown district. The stone is a white hypersthene-olivine-chondrite of the Baroti type with only little nickel-iron.

MR. M. H. HEY: *Studies on the zeolites. Part VIII.* A theory of the vapour-pressure of zeolites. An equation for the water-vapour pressure of a zeolite (or other compound showing similar dissociation phenomena) is derived on simple kinetic grounds, and is shown to agree reasonably well with the available experimental data. The equation, which can only be a first approximation to the truth, is compared with other equations previously proposed. Kinetic treatment also leads to a reasonable equation for the rate of diffusion of water within a zeolite crystal. The condition of the water in the zeolites is discussed.

NEW YORK MINERALOGICAL CLUB

Minutes of the May Meeting, 1933

The New York Mineralogical Club held a regular meeting at The American Museum of Natural History on Wednesday evening, May 17th, 1933. President Hawkins called the meeting to order at 8:24 P.M. The attendance was 60. Mr. William S. Downin of Nutley, N.J., was elected an active member.

It was decided to have the usual club excursion to Bedford, N.Y., on May 30th, and another excursion to the Somerville Mine on June 11th. Mr. Stanton called attention to a specimen of kaolinite, pseudomorphic after malacolite found at 169th Street and Center Avenue, N.Y. City, by Fred Braun, and recommended that it be placed in the Club's collection of New York City minerals.

The meeting was then turned over to the members for a symposium on calcite:

Mr. Frederick I. Allen discussed the causes of interference colors in Iceland spar and exhibited a specimen from Paterson, N.J. Mr. George E. Ashby described sand calcites and exhibited specimens of these from Fontainebleau, France; Vienna, Austria; and Washington County, South Dakota. He also exhibited the following specimens from his collection: spire calcite, paper calcite, globular calcite, amethyst calcite twin and calcite with "caps". Unusual specimens of calcite were also exhibited by James F. Morton, E. A. Maynard, John Reiner, Herbert Whitlock, J. W. Radu and A. C. Hawkins.

The meeting closed following a supplementary symposium on fluorescence, which Mr. Weidhaas began by calling attention to the argon tubes recently introduced on the market, which cause calcite from West Paterson to give a yellow phosphorescence; Mr. Radu continued with an account of the superior effects produced by the iron arc with Corning UV glass; while Mr. Broadwell defended the excellent behavior of the argon lamp with sphalerite from South Africa. So much interest was shown in the subject of fluorescent minerals that it was decided to devote one of the meetings of the Club to this subject.

DANIEL T. O'CONNELL, *Secretary*

Minutes of the October Meeting, 1933

The New York Mineralogical Club resumed its meetings in the fall when its members gathered at The American Museum of Natural History on the evening of October 18th, 1933. In the absence of the President, Vice-President Ashby called the meeting to order.

Professor Edward Salisbury Dana of New Haven, Conn., was elected an Honorary Member. On a motion by Mr. Frederick I. Allen, a committee consisting of the five officers of the Club was appointed to prepare the parchment certificate of

honorary membership.

It was proposed and carried that a Nico Lamp with a fluorescent mineral exhibit be presented to The American Museum of Natural History as a memorial to the late Dr. Kunz, founder of the Club, who, with Professor Charles Baskerville, was a pioneer in experimenting with fluorescent minerals, also that part of the money willed to the Club by Dr. Kunz be used to defray the expense of the installation.

Mr. Manchester reported an attendance of about 100 persons on the Club's Memorial Day excursion to Bedford Quarries. Among the rare finds made there were columbite, autunite, and torbernite by Mr. Jeffries, and peristerite by Dr. Rainsford.

Mr. McClelland, Principal of Eastchester High School, distributed polished pieces of the recently discovered Red Serpentine from Ridge Street between Rye and Portchester, N.Y. The meeting was then turned over to the members to report on their summer collecting experiences.

The following members also reported on their collecting experiences: Mr. Broadwell, marcasite nodules from Sayreville, N.J.; Mr. Maynard, minerals and photographs from Nova Scotia localities; Mr. Boyle, fluorescent wernerite from Quebec; Mr. Yedlin, quartz from Ellenville and manganpectolite ball from Paterson; Dr. O'Connell, weathered biotite recently mistaken for gold in the Bronx; Mr. O. I. Lee, thorianite; Mr. Grenzig, agate showing interference colors; and Mr. Manchester, strontiano-calcite from Franklin Furnace, N.J.

DANIEL T. O'CONNELL, *Secretary*